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# LUNG CAPACITY OF CHILDREN

## SPIROMETER TESTS OF 1,618 WHITE SCHOOL CHILDREN (751 BOYS, 867 GIRLS) IN THE CITY OF X

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# LUNG CAPACITY OF CHILDREN.

## SPIROMETER TESTS OF 1,618 WHITE SCHOOL CHILDREN (751 BOYS, 867 GIRLS) IN THE CITY OF X.[1]

By C. W. Stiles, Professor of Zoology, and Floyd Graves, Acting Assistant Surgeon, United States Public Health Service.

Of the white school children of the city of X, dry-spirometer tests (for lung capacity or "vital capacity") are available for 1,618 pupils (751 boys, 867 girls) from 6 to 17.75 years old, inclusive.

Each child was given three trials, and the highest record was taken for final summary. The tabulations were made by sex, by quarter years that are then summarized by total years, and by sanitary conditions of the home as respects presence of a privy (Group P), presence of sewer connection but no privy (Group S), and homes of unknown sanitation (Group U).

### White Boys.

Of 751 white boys for whom the results of spirometer tests are comparable, 583 belong to Group S, 110 to Group P, and 58 to Group U.

*Average spirometer tests for total year periods.*—There is an annual average increase in the lung capacity from 6 years to 17 years, and this increase becomes especially marked from 14 to 16 years. The conditions are shown on Chart 1.

Of the 12 total year periods from 6 to 17, inclusive (chart 2), the boys of group S excelled those of group P in 8 periods, and in 4 periods the boys of group P excelled those of group S.

*Average for quarter-year periods.*—In 23 quarter-year periods group S excelled, in 14 periods group P excelled, and 11 periods could not be compared. In some instances the groups were reduced to very small numbers.

### White Girls.

Of 867 white girls for whom the results of spirometer tests are comparable, 660 belong to group S, 166 to group P, and 41 to group U.

*Average spirometer tests for total year periods.*—As shown on chart 1, there is an increase in the lung capacity from 6 to 17 years. This increase shows an irregularity at 8 and 11 years, but is fairly uniform up to 13 years. From 14 to 17 years there is a marked decrease of the increase.

In 7 total year periods group S distinctly excelled group P, in 5 total year periods group P excelled group S, but in 2 of these periods the excess in favor of P was slight.

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[1] For other articles on the school children of the city of X, see Public Health Reports as follows: Difficulties in obtaining ages, v. 30 (5), Jan. 29, pp. 310–311; Zooparasitic Infections, v. 30 (27), July 2, 1915, pp. 1991–2002; School Grades, v. 30 (28), 1915, pp. 2060–2067; Tobacco and snuff, v. 30 (40), Oct. 1, 1915, pp. 2926–2928; Heights and Weights, v. 30 (41), Oct. 8, 1915, pp. 2990–3003.

Reprint from the Public Health Reports, vol. 30, No. 42, Oct. 15, 1915.

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TABLE 1.—*Average, minimum, and maximum lung capacity (vital capacity), as measured in cubic centimeters with dry spirometer, of 751 white boys and 867 girls 6 to 17.75 years old, inclusive, summarized in total year periods and sanitary groups.*

[P=children from homes provided with a privy; S=children from homes with sewer connection but without a privy; U=home sanitation unknown; T=total of P, S, and U.]

| Age. | Spirometer in cubic centimeters. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 751 boys. | | | | 867 girls. | | | |
| | Number of pupils. | Average. | Minimum. | Maximum. | Number of pupils. | Average. | Minimum. | Maximum. |
| 6 years, S. | 26 | 1,015.39 | 640 | 1,520 | 30 | 849.33 | 400 | 1,360 |
| 6 years, P. | 5 | 1,232.00 | 800 | 1,440 | 5 | 896.00 | 800 | 1,120 |
| 6 years, U. | 1 | 1,120.00 | 1,120 | 1,120 | 1 | 800.00 | 800 | 800 |
| T. | 32 | 1,052.50 | 640 | 1,520 | 36 | 854.44 | 400 | 1,360 |
| 7 years, S. | 57 | 1,226.32 | 720 | 1,760 | 41 | 1,075.12 | 640 | 1,760 |
| 7 years, P. | 14 | 1,137.14 | 640 | 1,600 | 15 | 1,120.00 | 720 | 1,520 |
| 7 years, U. | 4 | 1,180.00 | 1,120 | 1,360 | 6 | 1,173.33 | 1,040 | 1,360 |
| T. | 75 | 1,207.20 | 640 | 1,760 | 62 | 1,095.48 | 640 | 1,760 |
| 8 years, S. | 64 | 1,390.63 | 640 | 2,000 | 46 | 1,208.70 | 800 | 1,680 |
| 8 years, P. | 14 | 1,205.71 | 640 | 1,680 | 15 | 1,056.00 | 640 | 1,520 |
| 8 years, U. | 2 | 1,320.00 | 1,280 | 1,360 | 2 | 1,360.00 | 1,040 | 1,680 |
| T. | 80 | 1,356.50 | 640 | 2,000 | 63 | 1,177.14 | 640 | 1,680 |
| 9 years, S. | 75 | 1,461.33 | 720 | 2,240 | 56 | 1,281.42 | 800 | 2,080 |
| 9 years, P. | 13 | 1,415.38 | 1,040 | 2,000 | 21 | 1,436.19 | 800 | 1,920 |
| 9 years, U. | 5 | 1,344.00 | 800 | 1,840 | 6 | 1,280.00 | 1,040 | 1,760 |
| T. | 93 | 1,448.60 | 720 | 2,240 | 83 | 1,320.48 | 800 | 2,080 |
| 10 years, S. | 77 | 1,697.66 | 640 | 2,400 | 72 | 1,508.89 | 880 | 2,400 |
| 10 years, P. | 12 | 1,486.67 | 800 | 1,920 | 20 | 1,444.00 | 1,040 | 1,920 |
| 10 years, U. | 9 | 1,582.22 | 1,040 | 2,000 | 2 | 1,520.00 | 1,440 | 1,600 |
| T. | 98 | 1,661.22 | 640 | 2,400 | 94 | 1,495.32 | 880 | 2,400 |
| 11 years, S. | 56 | 1,833.21 | 1,200 | 3,040 | 65 | 1,636.91 | 1,040 | 2,320 |
| 11 years, P. | 21 | 1,672.38 | 1,040 | 2,480 | 17 | 1,487.05 | 960 | 2,320 |
| 11 years, U. | 5 | 1,808.00 | 1,360 | 2,080 | 3 | 1,786.67 | 1,440 | 2,240 |
| T. | 82 | 1,789.27 | 1,040 | 3,040 | 85 | 1,612.23 | 960 | 2,320 |
| 12 years, S. | 53 | 2,052.83 | 1,440 | 2,880 | 59 | 1,865.76 | 1,200 | 2,960 |
| 12 years, P. | 11 | 1,905.45 | 1,360 | 2,720 | 16 | 1,875.00 | 1,280 | 2,480 |
| 12 years, U. | 7 | 2,217.14 | 1,440 | 3,760 | 5 | 2,000.00 | 1,760 | 2,400 |
| T. | 71 | 2,046.20 | 1,360 | 3,760 | 80 | 1,876.00 | 1,200 | 2,960 |
| 13 years, S. | 55 | 2,144.73 | 1,600 | 3,520 | 74 | 2,151.35 | 1,440 | 3,040 |
| 13 years, P. | 8 | 2,410.00 | 1,840 | 3,200 | 18 | 2,013.33 | 1,280 | 2,800 |
| 13 years, U. | 3 | 2,933.33 | 2,160 | 3,520 | 2 | 2,040.00 | 2,000 | 2,080 |
| T. | 66 | 2,253.63 | 1,600 | 3,520 | 94 | 2,122.55 | 1,280 | 3,040 |
| 14 years, S. | 36 | 2,500.00 | 1,520 | 3,520 | 68 | 2,181.47 | 800 | 3,200 |
| 14 years, P. | 4 | 2,775.00 | 1,760 | 4,320 | 20 | 2,188.00 | 1,440 | 2,640 |
| 14 years, U. | 9 | 2,484.44 | 1,820 | 3,680 | 5 | 3,024.00 | 1,360 | 3,040 |
| T. | 49 | 2,520.41 | 1,520 | 4,320 | 93 | 2,228.17 | 800 | 3,200 |
| 15 years, S. | 41 | 2,926.83 | 1,840 | 3,840 | 58 | 2,306.21 | 1,360 | 3,240 |
| 15 years, P. | 4 | 2,720.00 | 2,000 | 3,440 | 13 | 2,172.31 | 1,280 | 2,800 |
| 15 years, U. | 10 | 2,839.00 | 1,920 | 4,160 | 3 | 2,426.67 | 2,240 | 2,560 |
| T. | 55 | 2,895.81 | 1,840 | 4,160 | 74 | 2,287.57 | 1,280 | 3,240 |
| 16 years, S. | 30 | 3,334.67 | 1,840 | 4,880 | 60 | 2,422.67 | 1,520 | 3,200 |
| 16 years, P. | 2 | 2,880.00 | 2,880 | 2,880 | 5 | 2,288.00 | 1,760 | 2,560 |
| 16 years, U. | 1 | 2,000.00 | 2,000 | 2,000 | 5 | 2,032.00 | 1,600 | 2,320 |
| T. | 33 | 3,266.66 | 1,840 | 4,880 | 70 | 2,385.14 | 1,520 | 3,200 |
| 17 years, S. | 13 | 3,353.85 | 2,240 | 4,880 | 31 | 2,400.00 | 1,760 | 3,360 |
| 17 years, P. | 2 | 3,720.00 | 3,440 | 4,000 | 1 | 2,320.00 | 2,320 | 2,320 |
| 17 years, U. | 2 | 4,240.00 | 4,000 | 4,480 | 1 | 3,200.00 | 3,200 | 3,200 |
| T. | 17 | 3,501.18 | 2,240 | 4,880 | 33 | 2,421.82 | 1,760 | 3,360 |

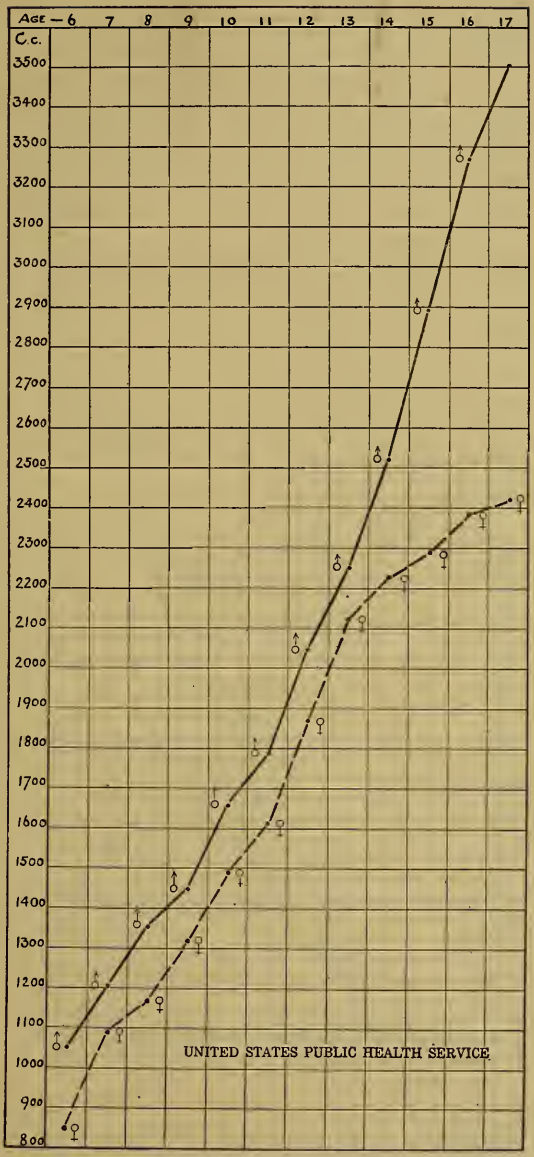


CHART 1.—Average lung capacity, measured in c. c. with dry spirometer, of 751 white boys (♂) and 867 white girls (♀), summarized in total year periods.

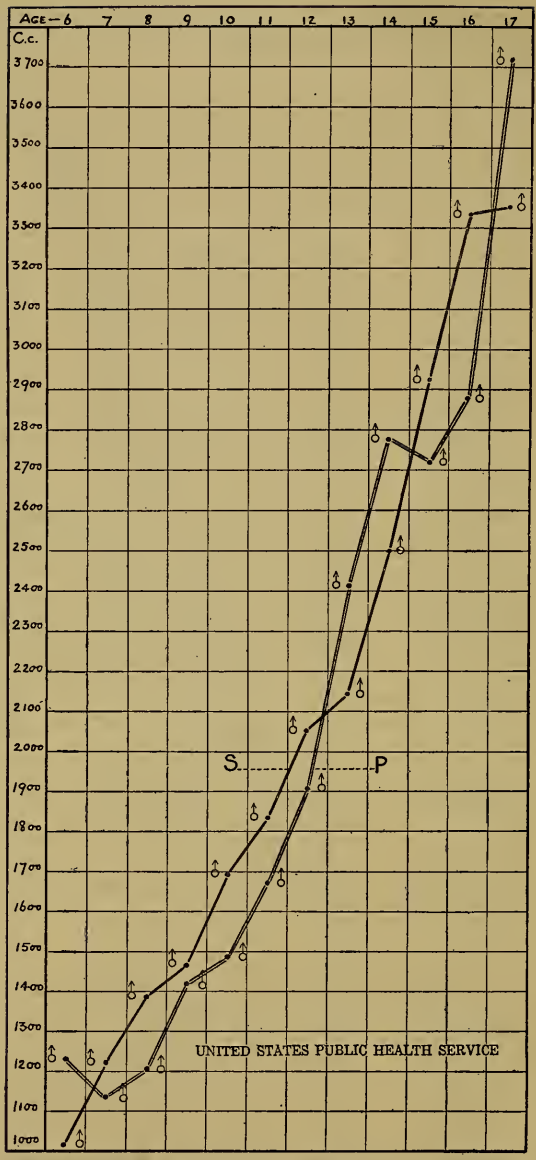


CHART 2.—Average lung capacity, measured in c. c. with dry spirometer of 583 white boys of Group S and 110 of Group P.

*Average for quarter-year periods.*—In 23 quarter-year periods group S excels, in 17 group P excels, and in 8 periods no comparison could be made. In some periods the groups contain few pupils.

### Comparison of Boys and Girls.

If chart 1 be studied, the fact becomes evident that the average lung capacity, as measured by a dry spirometer, averages about 100 to 200 cubic centimeters higher in boys than in girls from 6 to 13 years old, inclusive. At 14 years old a very greatly increased

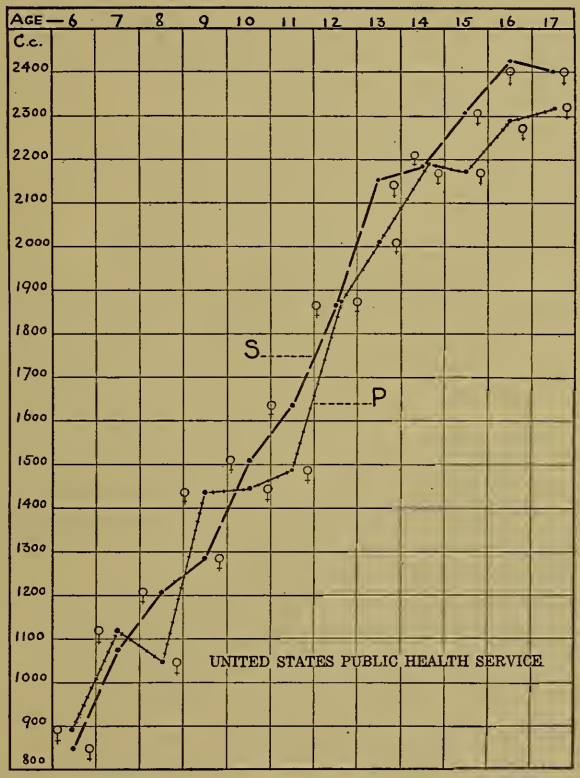


CHART 3.—Average lung capacity, measured in c. c. with dry spirometer, of 660 white girls of Group S and 116 of Group P.

difference in lung capacity becomes evident in favor of the boys, and this difference increases from 14 to 17 years, inclusive; at 17 years the difference between the boys and girls is very marked (nearly 1,100 cubic centimeters).

### Spirometer Tests in Intestinal Infections.

*Necator.*—In 22 cases (15 boys, 7 girls) pupils showing hookworm infections were lower in lung capacity than the average for their respective groups, and in 31 cases (24 boys, 7 girls) they were above the average.

*Ascaris.*—In 15 cases (11 boys, 4 girls) pupils showing *Ascaris* infection were lower than the average for their respective groups, and in 23 cases (21 boys, 2 girls) they were above the average.

*Trichuris.*—In 7 cases (6 boys, 1 girl) pupils showing infection with whip worms were lower than the average of their respective groups, and in 1 case (a boy) the pupil was above the average.

*Lamblia.*—In 34 cases (22 boys, 12 girls) pupils showing infection with *Lamblia* were lower than the average of their respective groups, and in 39 cases (32 boys, 7 girls) they were above the average.

*Endamæba coli.*—In 24 cases (18 boys, 6 girls) pupils showing infection with *E. coli* were lower than the average of their respective groups, and in 27 cases (18 boys, 9 girls) they were higher than the average.

### Summary and Conclusion.

From 6 to 13 years old, inclusive, the white boys of the city of X average from 100 to 200 cubic centimeters greater lung capacity (as measured by the dry spirometer) than the girls. From 14 to 17 years the boys have progressively from about 300 to about 1,100 cubic centimeters greater lung capacity than the girls. Thus the increase in high-school age (athletic age) in the boys is out of all proportion to the increase in primary and grammar (graded) school age.

From 6 to 13 years old, inclusive, the yearly increase in the lung capacity of the girls of the city of X is very similar to that of the boys, but at 14 there develops a distinct decrease of the increase, and from 14 to 17 years, inclusive, the annual increase averages distinctly less than for the years 6 to 13.

The decrease of the increase at 14 years in the girls follows immediately upon the average age of beginning menstruation (13.2 years), and it corresponds with the decrease of the increase in height (sitting and standing) and weight.

There is a slight irregularity of the increase curve at 11 in both boys and girls, corresponding to the irregularity found for the same year in the curves for height (sitting and standing) and weight in the boys and for sitting height in the girls.

In the case of both the boys and the girls, children from homes provided with better sanitation (group S) have a tendency (total, 15 to 9; boys 8 to 4, girls 7 to 5; estimated in year groups) to greater lung capacity than the children from homes with poorer sanitation (group P; total, 9 to 15; boys 4 to 8, girls 5 to 7).

In cases of intestinal infection it was not evident that hookworms, *Ascaris*, *Lamblia*, or *Endamæba coli* had any noticeable effect upon the spirometer tests. While pupils with whipworm infections showed a preponderance of tests lower than the average, the number of cases is so small that conclusions are of doubtful value.

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